RMA/IND - EMCAT - LPD - C1

Energy Management Consultation and Training Project (EMCAT): Loan Portfolio Development Project (LPD)

Pre-Investment Survey
Cement Industry

June 1995

Prepared by: Alex Mishulovich, consultant to
Resource Management Associates of Madison, Inc.

Prepared for: United States Agency for International Development (USAID)
New Delhi, India
Contract Number: 386-05127-C-00-4100-00

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Preface

This report covers the pre-investment survey activities of the Indian cement industry as conducted by Mr. Alex Mishulovich for Resource Management Associates of Madison, Inc. (RMA) under the Energy Management Consultation and Training Project (EMCAT). EMCAT is funded by the U.S. Agency for International Development (USAID) for which RMA serves as the prime contractor in implementing the project. Under this contract, RMA will provide consulting services until April 1997.

In the course of his work, Mr. Mishulovich surveyed four plants representative of the latest generation of the Indian cement sector plants. All results are being forwarded to Project partners and funding agencies, but proprietary information is not being shared among the surveyed plants.

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1. EXECUTIVE SUMMARY

This report contains the results of the inspection of four Indian cement plants conducted with the objective of outlining the areas where implementation of energy-saving technology would directly benefit the company. The author's suggestions and the companies' plans for upgrading the process systems were discussed in detail and subjected to technical, as well as simplified financial, analysis.

Energy costs (fuel and electric power) are responsible for more than half of the direct production costs at an average cement plant in India, and the awareness of the energy problem is quite high, especially due to the fact that most energy conservation measures are also directly related to the general upgrading of the process technology.

The plants inspected within this project utilize post-1980 technology, and are operated according to sound, commonly accepted practices. Nevertheless, even the cursory inspection identified certain areas in need of improvement. The plant management and technical personnel being aware of most of the problems were fully cooperative, and the ensuing discussions helped to identify and prioritize the proposed process changes.

This report contains only the major suggestions requiring investments for their implementation. In some cases, technically complex measures of modernization are briefly discussed but not quantified because the relevant data are not available without a special engineering study. In other cases, the investment cost was well defined but the prospective energy savings represented the secondary effect and could be estimated based only on some crude assumptions. Some improvements (e.g., conversion of open-circuit mills to closed-circuit) represent transition to the latest technology; others (e.g., replacement of multi cyclones with baghouses) reflect increased environmental awareness. All companies expressed their willingness to implement the proposals provided the funding is available. Simple paybacks for the recommended upgrades ranges from 0.7 years to 12.0 years, with the average payback, if all projects were implemented, being 6.3 years. If all projects were implemented, the 6.90 million rupee investment would save 23,680,000 kWh of electricity and 16.6.300 Gcal (660,000 MMBtu) of coal each year.

The plants inspected within this project represent the most technically advanced part of the Indian cement industry. In the meantime, modernization can yield the highest return on investment if implemented at the older plants. It is advisable that a similar project be undertaken to evaluate a representative sampling of plants of the previous generation. *Table 1.1* displays a summary of the recommended changes at each of the plants surveyed.

Table 1.1 Summary of Recommendations

Plant	Process Changes	Cost (mil. Rs.)	Savings (mil. Rs./yr)	Payback Period (years)
Shree Cement	Roller mill modification	14.3	3.09	4.6
	Kiln modification	184.0	28.5	6.5
Subtotal		198.3	31.6	6.3
Mangalam Cement	Pneumatic conveying replacement	36.2	3.6	10.2
	Upgrading coal burner	5.0	7.4	0.7
	Kiln modification	19.0	12.2	1.6
Subtotal		60.2	23.2	2.6
Satna Cement	Building preblending coal storage	170.0	14.0	12.0
	Pneumatic conveying replacement	36.0	8.0	4.5
	Preheater modification	45.0	4.0	11.0
Subtotal		251.0	26.0	9.6
Century Cement	Pneumatic conveying replacement	60.0	13.3	4.5
	Raw material preparation system	120.0	15.9	7.5

Subtotal	180.0	29.2	6.2
TOTALS	**690.0**	**110.0**	**6.3**

2. INTRODUCTION

Project Description

The United States Agency for International Development (USAID) is sponsoring a three-year program of energy efficiency improvement within the country of India. Resource Management Associates of Madison, Wisconsin U.S.A. has been given the responsibility of carrying out this task. One portion of this project focuses on industrial energy utilization. The reports will be concentrating on large process modernization changes that will reduce energy consumption. These process technology reviews will be used in Loan Portfolio Design (LPD) for the Industrial Development Bank of India (IDBI). A major Project goal is to develop loan packages to finance implementation of industry process changes which will reduce India's energy consumption.

Purpose of the Survey

The purposes of this survey were to:

- Evaluate the existing process technology and its energy intensity per unit of output.
- Evaluate how "state-of-the-art" technology, as available on the world market, would affect the energy intensity per unit of output.
- Estimate the simple payback of the financial investments required to implement energy-efficient process changes.

Plant Survey Process

This activity was completed in two phases. The first phase was for a local cement process specialist to complete basic plant process information. This task was completed by Holtec Engineers of New Delhi. This information was shared with the U.S. consultant to assist in his preparation prior to his visit. The second phase was for the U.S. and Indian process specialists to physically review the planbts' operations together. This was completed with the cooperation and assistance of each plant's process staff.

Technical Background

Portland cement concrete is the most widely used material in today's construction industry because of its structural properties, durability, and economy. Portland cement is the essential ingredient of concrete, and its annual production, worldwide, rose from 30 million metric tons in 1918 to the present level of 1.2 billion tons. This makes the cement industry the largest among process industries in terms of the product output.

The cement production process starts with intergrinding a properly proportioned mixture of quarried argillaceous (clay or shale) and calcareous (limestone) materials. This mixture is fired in a rotary kiln at temperatures about 1450°C until it partially fuses and produces the new material in the form of nodules called clinker. Clinker ranging in size from 5 to 75 mm in diameter is subsequently interground with approximately 5% of gypsum to produce the final product, portland cement. Blast furnace slag or pozzolans (natural or artificial) can be added during grinding. In this case, the resulting products are called, respectively, portland-slag and portland-pozzolan cements.

The strength of hardened cement paste determines the strength of the most common cement-based materials, mortar and concrete. Therefore, it is the most important characteristic of the product. For control purposes, the strength of cement is determined in standard specimens which are prepared, cured, and tested under specified conditions. The standards of many countries divide cements into classes, or grades, according to the strength. In the Indian national standards, grade designations of 33, 43, and 53 refer to the compressive strength (in MPa) of mortar cubes tested at 28-day age.

The environmental effects of cement production include: (1) use of raw materials, (2) use of non-renewable energy resources, and (3) emission of particulate and gaseous substances.

Portland cement manufacture does not require the use of rare natural resources but is an energy-intensive process. The average cement industry energy consumption (including both fuel and electric power) is approximately 1330 kcal/kg (5570 kJ/kg) of the product. Out of this total, virtually all fossil fuel consumed by a cement plant is used in the kilns where clinker is produced. Electricity makes up 9.9% of the total energy use. Electrical energy is used for material acquisition and preparation of raw feed for burning in the kiln. This electricity provides power to primary and secondary crushing equipment, the raw mill, and various motors associated with blending, conveyors, and dust collection. Approximately 25% of the total electric energy is used for raw grinding, but the amount may vary widely depending on the plant configuration. The finish grinding process uses 38% of the total electrical energy.

The vast production scale and high energy requirements of the cement industry make the energy aspect critically significant. Energy-efficient operation of the major equipment possesses the greatest potential for the general efficiency improvement. This is why the major technical developments of the last decades have targeted reduction of energy use.

3. SHREE CEMENT LTD.

3.1 Plant Executive Summary

Shree Cement Plant is located near Beawar, Rajasthan in India. It produces portland and portland-pozzolan cements. The main energy sources used in the plant are coal and electricity. Coal is used to produce heat in the kiln. Electricity is used in motors to drive grinders and pneumatic conveying fans.

The plant's process is designed to include the world's latest cement plant technology. Its kiln operation was reported to consume 800 kcal/kg of energy as compared with the world's best plants which operate at about 700 kcal/kg. Although the plant is very modern, several opportunities exist to improve plant energy efficiency.

Energy conservation opportunities within the plant include:

1) ATOX Roller Mill modification; and
2) Kiln system modification.

By implementing these energy saving concepts, the plant will reduce electricity consumption by an estimated 7,302,000 kWh of electricity, and 21,500 Gcal (85,300 MMBtu) of coal savings of Rs. 23,400,000 (US$ 75,000) will pay back the Rs. 198,300,000 (US$ 6,397,000) investment in 8.5 years.

If addition production income is considered, the investment payback becomes 6.3 years.

3.2 Characteristics of the Existing Process

The plant owned by Shree Cement Limited is located near Beawar, Rajasthan. It produces portland and portland pozzolan cements. The rated capacity is 570,000 tpy (tons per year) clinker, 600,000 tpy cement. However, the actual production rate has reached 870,000 tpy. The principal raw materials are limestone (two grades) and laterite as a corrective addition. The low-grade limestone is mined and crushed at the quarry in a 400 tph impact mill and transferred by a ropeway to the plant site. Along with purchased high-grade limestone, the low-grade limestone is stockpiled in the storage equipped with a longitudinal stacker/reclaimer for pre-homogenization of the material.

Raw meal is ground in a 245-tph ATOX vertical mill. The mill utilizes kiln gas heat energy for simultaneous drying and is an integral part of the pyroprocessing system. The ground raw meal is collected in two cyclones and an electrostatic precipitator. It is next transferred to the blending and storage silo.

The kiln is 3.95 m x 56 m in size and was originally rated at 1,800 tpd. The actual capacity is close to 3000 tpd. The kiln is equipped with a four-stage preheater, in-line precalciner, and FOLAX three-grate cooler with a 64.2 m^2 grate area. The plant uses local coal with addition of approximately 20% Assam coal. The coal grinding plant consists of a ATOX vertical roller mill with a dynamic classifier. The mill is rated at 25 tph.

Clinker is discharged to a circular hollow-shaft stockpile. It is further transferred into the finish mill bins. Finish grinding done by a 120-tph closed-circuit ball mill (120 tph, 4.4 x 13.5 m) with a high-efficiency SEPAX classifier.

The raw meal chemical composition is maintained based on the XRF analysis of hourly samples of raw meal, kiln feed, and clinker. The clinker chemical composition is maintained within the reasonable range of variability. The principal operation parameters of the process equipment are also maintained stable.

The plant process design and the major equipment represent the latest trends in the world cement manufacturing technology. The plant also compares favorably with many U.S. plants built in the last decade in terms of performance characteristics.

The principal operational problems are those related to the poor agglomeration of material during clinkering. Formation of the clinker nodules in the kiln is impeded by some undetermined process factors. As a result, dust and fine fractions are abundant in clinker which reduces burning and cooling efficiency. Such material behavior may be connected to a number of raw material and burning characteristics. It was suggested that the company commission a study in order to optimize the burning process and clinker granulometry.

3.3 Energy Intensity of the Existing Process

The kiln operation, being the most fuel-intensive part of the process, is characterized by moderate fuel consumption. According to the calculations provided by the plant, the specific heat consumption is about 800 kcal/kg. This number is moderate, although the best systems worldwide operate with the heat consumption close to 700 kcal/kg. The operational problems mentioned above are partly responsible for relatively high heat losses resulting in cooler vent air and flue gas. Finer adjustments of the kiln operation may be needed to attain the more economical performance.

The company made available the internal data on the production and energy use by the principal process equipment. *Table 3.1* summarizes the data.

Table 3.1 Power Consumption in Production, kWh/t clinker

	1993 - 1994	January 1995
Crusher	1.55	1.9
Raw mill	20 - 205	20.7
Coal mill	3.2 - 3.5	3.3
Kiln	28 - 29	28.6
Finish mill	33 - 34	34.5
Packing	1.5	1.3
Total	89 - 90	90.3

These indicators are quite satisfactory. The company has implemented a number of measures which reduce power consumption by 20% as compared to 1989-90. Among these are replacement of pneumatic conveyors by bucket elevators for kiln feed, raw meal silo, and cement silos; installation of a high-efficiency separator for the finish mill and dynamic separators for raw and coal mills; and modifications of electric drives and power distribution systems. The latest improvement was the replacement of conventional cyclones with low-pressure drop cyclones in the first stage of the preheater. The pressure loss across the preheater decreased by 100 kg/m^2, or about 12%.

Finish grinding and clinker burning remain the most energy-intensive processes, and the latter can be further improved in terms of both power and fuel consumption.

3.4 Description of Proposed Process Changes

Two major projects aimed at the further energy conservation have been discussed with the company technical and managerial personnel and can be recommended for implementation.

1. External (mechanical) recirculation of material in the raw mill. Presently, the material is

lifted from the mill table and conveyed into the mill separator by gas flow. Since this material contains coarse particles, the required gas velocity is relatively high which results in high volume and pressure loss and, subsequently, high power consumption by the fan drive. If the gas velocity is reduced, only fine particles would be conveyed to the separator. Coarse particles will be discharged from the table into the bucket elevator and returned for additional grinding. The power consumption by such conveying system is significantly lower than the power saved by the fan motor.

2. Modification of the pyroprocessing system. The principal part of this project is addition of a five- or six-stage preheater string with a precalciner. This would increase the kiln production rate to 3200-3300 tpd. Pressure loss across the preheater would be reduced to 400 - 450 kg/m^2 with resulting power savings of about 5 to 6 kWh/t by the exhaust fan. Specific heat consumption would be reduced by 15 - 25 kcal/kg.

To accommodate the increased clinker production, modification of the existing grate cooler will be required including installation of a modernized air-beam grate system by IKN Co. (Germany). Additional fans, coal firing equipment, and kiln drive modifications would be included in the package.

3.5 Energy Saving Projections for Process Changes

The projected energy savings from the proposed modifications are as follows:

1. ATOX Roller Mill modification:		1.5 kWh per ton clinker
2. Kiln system modification:	fuel	15-25 kcal/kg clinker
	power	5-6 kWh/t cement, additional clinker production 250 tpd

3.6 Cost Estimate of Proposed Process Changes

1. ATOX Roller Mill modification:

Equipment (imported and indigenous), installed	11,200,000
Civil works, electrical and instrumentation, contingency	3,100,000
Total (rounded)	Rs. 14,300,000

2. Kiln system modification:

Equipment	103,500,000
Civil works, erection and fabrication, other costs, contingency	80,500,000
Total	Rs. 184,000,000

3.7 Simple Economic Payback Based on Energy Savings

1. ATOX Roller Mill modification.

Based on actual cement production of 935,000 tpy and the savings of 1.5 kWh/t, the annual energy savings are (kWh):

$$935{,}000 \times 1.5 = 1{,}402{,}000$$

At the electric power cost of Rs. 2.20 per kWh, the total annual savings are (Rs.):

$$1{,}402{,}000 \times 2.2 = 3{,}085{,}000$$

With the cost of the modification Rs. 14300000, the payback period is:

$$14300000 \div 3085000 = 4.6 \text{ yrs}$$

If the raw mill modification is implemented in conjunction with the kiln upgrading, the production rate of both systems would provide for an annual production rate of about 1,200,000 tons (cement). In this case, the payback period would be:

$$14300000 \div (1200000 \times 1.5 \times 2.2) = 3.6 \text{ yrs}$$

2. Kiln system modification.

At the projected power savings of 5.5 kWh/t, the daily production rate of 3250 t, and 330 days of operation annually, the total power savings are (kWh):

3,250 x 330 x 5.5 = 5,900,000

At the energy cost of Rs. 2.2 per kWh, the annual savings are (Rs.):

5,900,000 x 2.2 = 13,000,000

At the projected fuel savings of 20 kcal/kg clinker, the annual fuel savings are (million kcal):

20 x 3250 x 1000 x 330 = 21,500

According to the plant data, the average fuel price is Rs. 340 per one million kcal, and the annual savings are:

21,500 x 340 = Rs. 7,300,000

Additional clinker production is 250 tpd, or 82,500 tpy. The anticipated income from the additional clinker is Rs. 100 per ton, or 100 x 82500 = Rs. 8,250,000.

Total savings (Rs.):

Power savings	13,000,000
Fuel savings	7,300,000
Clinker realization	8,250,000
Total (rounded)	28,500,000

Payback calculation

Cost of the modification	184,000,000
Total savings	28,500,000
Payback period	184,000,000 ÷ 28,500,000 = 6.5 yrs

3.8 Additional Benefits

The modifications discussed above have a potential for the general improvement of the plant operation. Since these modifications increase the equipment capacity, the principal effect would be more stable performance and product quality. It is well known that the additional fuel combustion in the precalciner provides the operator with more flexibility in controlling the kiln. It will produce clinker of the desired quality more consistently and eliminate the necessity to over grind it to compensate for quality fluctuations. This, in turn, would reduce the unproductive power usage by the finish mills.

Shifting a larger portion of fuel combustion to the precalciner reduces the thermal load of the burning zone and consequently improves the refractory life span resulting in additional savings.

Improvement of cement quality would enable the plant to produce cement of higher market value and increase the percent of pozzolans in blended cements, thus increasing the profit margin. Therefore, taking into account all these factors, the actual payback period would be shorter.

3.9 Names, Addresses, Telephones of Contacts

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4. MANGALAM CEMENT

4.1 Plant Executive Summary

The Mangalam Cement Plant is located near Morak, Rajasthan in India. It produces ordinary portland cement grades 33 and 43. The plant energy sources are coal and electricity. Coal is used to produce heat in the kilns, and electricity is used to drive motors for grinding and pneumatic conveying.

The plant has two process lines. The older line was built in 1980, and the newer was built in 1994. The older line has not been updated since it was built. The new line is already operating at its design performance level. With both lines, the reported 900 - 925 kcal/kg clinker is fairly high by world industry standards. Experience is likely to be the solution in the new process line, while equipment upgrades are needed to improve the older process line.
Recommended energy efficiency upgrades to the older plant are:

1. Pneumatic conveying to mechanical conveying
2. Installation of a multichannel coal burner
3. Conversion from a preheater to a precalciner

The total investment necessary for implementation of upgrades is Rs. 60,200,000 (US$ 1,940,000). The estimated savings achieved through this investment is 3,780,000 kWh of electricity, and 31,800 Gcal (126,180 MMBtu) of coal. Saving this energy will result in annual cost savings of Rs. 19,185,000 (US$ 619,000). The average project payback is 3.1 years.

If additional production income is considered, the modifications will have a payback of 2.6 years.

4.2 Characteristics of the Existing Process

The plant is located near Morak, Rajasthan. It produces ordinary portland cement Grades 33 and 43, and operates two completely independent production lines. The older line was built in 1980 and has not undergone any major renovation since. This line has a capacity of 400,000 tpy. The new line operating under a separate corporate entity (Neer Shree Cement) is located at the same site. It started operations in 1994 and has already reached its design performance of 695,000 tpy. Raw materials for these production lines are: local low- grade limestone, purchased high-grade limestone, and various iron-containing materials (laterite, iron ore, etc.).

The old production line is using a 275 tph impact crusher for primary size reduction. Crushed limestone (25 mm in size) and other ingredients are transferred into the raw mill bins. The ingredients are fed by weighfeeders into the ball mill. The closed circuit, two-compartment mill is 4.2 x 8.25 m in size, rated at 115 tph. Raw meal is blended and stored in a double-decker silo. The rotary kiln 4.4 x 64.8 m in size is rated at 1200 tpd (actual production is slightly lower) and is equipped with a four-stage suspension preheater and a grate cooler. Fuel is usually a blend of local coals purchased at the spot market and 20% low-ash, medium-sulfur Assam coal. It is ground in a two-compartment air-swept ball mill. Finish grinding is done in two open-circuit mills 3.4 x 16 m, 74 tph mills.

The new production line (Neer Shree Cement) has a 500 tph impact crusher supplying 75-mm size limestone to the longitudinal pre-blending storage with a bridge stacker / reclaimer. A vertical roller raw mill is rated at 175 tph. A continuous flow blending silo is used for storing raw meal. Vertical mill is also used for coal grinding. The rotary kiln is 4 x 60 m in size, equipped with a 5-stage DOPOL precalciner and grate cooler. The kiln design capacity is 2000 tpd and the actual production rate is over 2100 tpd. Clinker is transferred to a circular open storage and processed separately from the old production line clinker. The finish grinding system producing consists of a Polycom roller press in closed circuit with a high-efficiency separator and open-circuit single-chamber ball mill. It is used to produce only Grade 43 cement. Unlike the Mangalam Cement production line, this one is equipped with a modern computerized process control system.

Operational problems are experienced in the pyroprocessing area of the older line. Frequent kiln malfunctions are caused by buildups in the transfer chamber (feed shelf). Brief observation and analysis of the operator's logs indicate that high and variable temperatures in the transfer chamber are the possible explanation. This temperature fluctuates as much as 150°C during a single shift and sometimes exceeds 1,100°C. The likely reason for such temperature conditions is unsatisfactory coal combustion. It is caused by, among other factors, inferior and highly variable coal quality. The tendency toward the buildups is enhanced by the increase of sulfur content when more Assam coal is used.

The coal moisture, heating value, and ash content vary almost daily. This coal variability also causes variations of the clinker chemical composition. As a result, the plant is forced to use finer grinding to comply with standard specifications under conditions of unstable clinker quality.

4.3 Energy Intensity of the Existing Process

The kiln operation, being the most energy-intensive part of the process, is particularly important for the general evaluation of energy efficiency. The plant reports coal consumption of approximately 0.22 t per ton clinker (old kiln) and 0.21 t per ton clinker (new kiln). However, the exact heating value of coal is not known, and the reported of 900 - 925 kcal/kg clinker can be accepted as a rough estimate. This corresponds, approximately, to the operation parameters observed during our visit. This number, however, is fairly high by the world industry standards.

It is likely that the new kiln will experience improved fuel efficiency when all problems of the post-commissioning period are corrected and the operating personnel attain the necessary experience. The older kiln needs improvements of operation and, possibly, installation of an advanced coal burner.

Poor coal quality remains the underlying reason for several operational problems, and its improvement and stabilization requires immediate attention.

Table 4.1 Power Consumption in Production, kWh/t clinker

	Mangalam Cement		**Neer Shree**	
	1993 - 94	**Dec. 1994**	**1993 - 94**	**Dec. 1994**
Crusher	2.75	2.85	n/a	2.00
Raw mill	41.51	42.60	n/a	26.07
Kiln / coal mill	51.65	53.59	n/a	41.2
Finish mill	45.18	41.43	n/a	42.80
Total	**142.33**	**137.33**	**n/a**	**111.10**

As *Table 4.1* demonstrates, new technology in general, and the vertical raw mill in particular, contribute to energy economy. The power consumption is high on the old plant primarily because of the obsolete ball raw mill. Although the open-circuit finish mill is hardly suitable for major modifications, it its performance improved as a result of modifications. These modifications have been implemented by Magotteaux, a specialized mill engineering company, at the cost of Rs. 5,850,000. The mill throughput increased by 10%, and the power consumption was reduced by 3-4 kWh/t.

4.4 Description of Proposed Process Changes

Some energy-saving process modifications are presently under consideration, and their economic effects can be evaluated. They include the following:

1. Replacement of pneumatic conveying systems for raw meal, kiln feed, and cement with mechanical (bucket elevator) conveying (old plant).

2. Installation of a multi-channel coal burner in order to improve coal combustion.

3. Installation of a coal burner in the riser duct of the old preheater (Mangalam Cement), thus converting it into a precalciner with the necessary modification of other kiln systems (ID fans, kiln drive, cooler, etc.).

Other measures are being suggested as a result of this project and may require further engineering study before any economic analysis can be done. In order to stabilize coal quality, it is proposed to build a pre-homogenizing coal storage complete with a stacker / reclaimer capable of holding a one- to two-week supply of coal. Although this alone would not improve the coal quality, it will reduce fluctuations of ash and moisture content in coals from different suppliers. Significant improvement can be achieved by installing a coal beneficiation plant. These measures would improve the plant operation although it is difficult to evaluate quantitatively the accrued benefits.

Besides the preheater / precalciner conversion, a large-scale modernization of the plant may require the following:

1. Installation of a vertical raw mill for the older kiln

2. Conversion of the existing ball raw mill into a closed-circuit finish mill (possibly, with a roller press)

3. Phasing out the old finish mills

4. Redesign of all material-handling systems.

4.5 Energy Saving Projections for Process Changes

It is projected that the following energy savings will be achieved by the modifications described below.

1. Replacement of pneumatic conveying systems with mechanical conveying.

According to the manufacturer, the following energy savings are anticipated:

A. For raw meal to blending silo:	1.6 kWh/t
B. Kiln feed from the blending silo to the kiln feed bin:	2.3 kWh/hr
C. Cement from the finish mill to cement silo	2.2 kWh/t
Total	6.1 kWh/t

For future considerations, a more conservative estimate of the total of 4 kWh/t should be used.

2. Installation of a multi-channel coal burner

It is estimated that this measure would reduce the preheater off-gas temperature by 40°C, reduce carbon monoxide emission to <0.1%, and improve kiln efficiency due to greater process stability. The overall effect would be equivalent to approximately 55 kcal/kg clinker, or 6% of the total.

3. Conversion of the preheater into a precalciner system.

This measure would result in estimated fuel economy of 25 kcal/kg, power economy of 5 kWh/kg, and additional clinker production of 120 tpd.

The major plant modernization suggested in Section 4.3 is likely to result in increased energy efficiency, the amount of which is difficult to estimate without a detailed study. The replacement of the existing ball raw mill with a vertical roller mill, alone, will save about 16 kWh/ton, or over Rs. 13,000,000 annually.

4.6 Cost Estimate of Proposed Process Changes

1. Replacing the pneumatic conveying systems with mechanical conveying.

The cost of this measure was estimated by the equipment supplier as follows (Rs.):

A. For raw meal to blending silo:	15,500,000
B. Kiln feed from the blending silo to the kiln feed bin:	8,900,000
C. Cement from the finish mill to cement silo	11,800,000
Total	36,200,000

2. Installation of a multi-channel coal burner

According to the quotation of the manufacturer (Pillard Inc.), burner replacement cost (including accessories) is Rs. 5,000,000.

3. Conversion of the preheater into a precalciner system (including additional coal firing equipment, ID fan replacement, upgrading the ancillary equipment, and civil works):

> No engineering data is available. Based on the cost of similar projects, our estimate is Rs. 19,000,000.

No cost estimate can be done presently for the suggested major modification of the production process (see Section 4.3).

4.7 Simple Economic Payback Based on Energy Savings

1. Replacing the pneumatic conveying systems with mechanical (bucket elevator) conveying At the annual production level of 400,000 ton, with energy savings of 4 kWh/ton and the power cost of Rs.2.22 per 1 kWh, the annual savings are (Rs.):

$$400000 \times 4 \times 2.22 = 3{,}550{,}000$$

The total cost of installing the mechanical conveying systems (Rs.) is:

36,200,000

The payback calculation is:

$$36200000 \div 3550000 = 10.2 \text{ yrs.}$$

2. Installation of a multi-channel coal burner.

It is estimated, the overall effect would be approximately 55 kcal/kg clinker, or:

$$55 \times 1{,}000 \times 1{,}200 \times 330 = 21{,}800{,}000{,}000 \text{ kcal/yr}$$

The average fuel price at the Mangalam plants is approximately Rs. 340 per one million kcal, and the annual savings are (Rs.):

$$21{,}800 \times 340 = 7{,}400{,}000$$

Payback calculation:

$$5{,}000{,}000 \div 7{,}400{,}000 = 8 \text{ months}$$

3. Kiln system modification.

At the projected power savings of 5 kWh/t, the daily production rate of 1320 t, and 330 days of operation annually, the total power savings of this measure are:

1320 x 330 x 5 = 2,180,000 kWh

At the energy cost of Rs. 2.2 per kWh, the annual savings are:

2,180,000 x 2.22 = Rs. 4,835,000

At the projected fuel savings of 25 kcal/kg clinker, the annual fuel savings are:

25 x 1,320 x 1,000 x 330 = 10,000 million kcal

With the average fuel price of Rs. 340 per one million kcal, the annual savings are;

10,000 x 340 = Rs. 3400,000

Additional clinker production is 120 tpd, or 39,600 tpy. The anticipated income from the additional clinker is Rs. 100 per ton, or 100 x 39,600 = Rs. 3,960,000.

Total savings:

Power savings	4,835,000
Fuel savings	3,400,000
Clinker realization	3,960,000
Total (rounded)	**Rs. 12,200,000**

Payback calculation:

Cost of the modification	19,000,000
Total savings	12,200,000
Payback period	19,000,00 ÷ 12,200,000 = 1.6 yrs

4.8 Additional Benefits

Both the replacement of the existing coal burner and the conversion of the preheater into a precalciner would directly increase the kiln production rate, reduce energy requirements, greatly improve kiln operation stability, and expand the operator's ability to control the process. It will consistently produce cement of the desired grade eliminating the need to over grind clinker in order to compensate for fluctuations in chemical composition. This alone would reduce power usage by the finish mills. It will also reduce the down time which, in turn, would lead to further resource economy.

Replacement of pneumatic conveying by mechanical devices would reduce the amount of false air in the preheater. The same effect would reduce draft in the preheater after the modification, resulting in fuel savings.

The company is planning to replace the multi cyclones of the cooler vent air system with an electrostatic precipitator. Although this would reduce clinker losses, the principal effect of this replacement would be decreased air pollution.

The problems caused by uncertain and unstable coal supplies are numerous and require immediate attention. Expanding and pre-blending the coal stockpiles at the plant site, while not resolving all these problems, appears to be a relatively simple way to reduce fluctuations of coal quality.

4.9 Names, Addresses, Telephones of Contacts

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5. SATNA CEMENT

5.1 Plant Executive Summary

The Satna Cement Plant is located near Satna, Madhya Pradesh in India. It produces grades 33 and 53 portland cement, sulfate-resistant portland cement, and portland-pozzolan cement. The energy sources used in the plant are coal and electricity. Coal is used for heating in the kiln, and electricity is used in motors which drive grinders and pneumatic conveyor fans.

The plant's process design leaves room for energy efficiency improvements. The Birla Vikas portion of the plant reported a 900 kcal/kg consumption, while the Satna portion reported 800 kcal/kg consumption. A 700 kcal/kg consumption has been achieved in the world's best plants.

Upgrades to improve plant energy efficiency include:

1. Construction of coal storage with a stacker/reclaimer and a coal beneficiation facility.
2. Replacement of pneumatic conveying with mechanical conveying.
3. Installation of three-channel coal burners
4. Modification of cyclones to reduce pressure drops.

By implementing the recommended upgrades, 86,000 Gcal (341,000 MMBtu) of coal, and 4,800,000 kWh of electricity could be saved. These measures would achieve an annual energy cost savings of Rs. 35,970,000 (US$ 1,160,000). This means that investment needed to implement improvements, which amounts to Rs. 257,900,00 (US$ 8,320,000) would be paid back in 7.2 years, on average.

5.2 Characteristics of the Existing Process

This plant owned by Birla Jute & Industries Ltd., Cement Division, is located near Satna, Madhya Pradesh. The plant consists of two production lines operating technically as separate companies but sharing some facilities. The older line (Birla Vikas Cement) was built in 1982-83 with a 2,500 tpd kiln, 4.35 x 64 m in size, complete with a two-string, four-stage preheater with a separate line precalciner and a grate cooler; a 260 tph closed-circuit ball raw mill; and two closed-circuit finish mills with a combined output of 190 tph. Most equipment was supplied by, or ordered to the specifications of, F. L. Smidth Co. of Denmark. The rated capacity is 800,000 tpy.

Another line (Satna Cement) was built by Fuller KCP in 1989 as a partial replacement for the facilities of the old wet process plant. It consists of a vertical raw mill and a 2,250 tpd rotary kiln, 4.27 x 61 m in size, complete with a five-stage preheater and in-line recirculating precalciner. Finish grinding is done by five fairly obsolete open-circuit ball mills with a combined capacity of about 185 tph.

Both lines share the limestone quarry, the primary crusher, and a ropeway which transfers limestone to the plant site. Crushed limestone is stockpiled in the longitudinal storage space with a bridge stacker / reclaimer.

The plant produces grades 33 and 53 portland cement (Satna Cement only), sulfate-resistant portland cement (Birla Vikas Cement only), and portland pozzolan cement. Some clinker is shipped to the company's Durgapur facility which produces portland slag cement. According to the laboratory records, product quality is quite stable and exceeds standard requirements by a healthy margin.

Principal problems encountered in the plant's operation stem from the poor and highly variable quality of coal. Coal purchased at the spot market has ash content sometimes exceeding 40% and fairly high moisture. Moreover, these characteristics differ in shipments from different suppliers. The raw meal chemical composition is stabilized by the process control system with a Siemens X-ray fluorescence (XRF) analyzer. Despite the use of XRF control, fluctuations of the ash amount and composition make it difficult to prepare raw meal properly. Similarly, kiln operation is also affected by the coal quality. The addition of better quality Assam coal increases the sulfur level in the system. This, along with chlorides contained in spray-tower water, sometimes leads to buildups in the bottom part of the preheater. The bypass system designed for partial removal of alkali chlorides is rarely, if ever, used. It appears that the cyclones of the Birla Vikas preheater are smaller than necessary. This results in the relatively high pressure losses across the preheater.

5.3 Energy Intensity of the Existing Process

The kiln operation is the most fuel-intensive part of the process. According to the data reported by the plant, the specific heat consumption (average on the monthly basis) is about 900 kcal/kg at the Birla Vikas and 800 kcal/kg at the Satna plant. The former number is higher than the accepted industry benchmark; the latter number also leaves some room for improvement.

This survey found that the older kiln (Birla Vikas) has relatively high exit gas temperatures, especially in the calciner string. This, along with the high oxygen content, causes increased fuel consumption.

The electric power consumption by the principal process departments is given in *Table 5.1.*

Table 5.1 Power Consumption in Production, kWh/t clinker

	Birla Vikas Cement		**Satna Cement**	
	1993 - 94	**Jan. 1995**	**1993 - 94**	**Jan. 1995**
Quarry / crusher	4.97	n/a	4.97	4.46
Raw mill	30.98	n/a	28.31	29.25
Kiln / coal mill	37.03	n/a	31.16	31.51
Finish mill	33.16	n/a	38.30	39.37
Total	**105.44**	**n/a**	**103.44**	**105.68**

Overall, the power consumption at both plants (production lines) may be considered moderate. Characteristically, the closed-circuit finish mills at Birla Vikas are more efficient than the obsolete finish mills at Satna Cement. Power usage by the Birla Vikas kiln system is higher, probably due to under sizing of the cyclones resulting in greater pressure drops.

The plant has already accomplished a number of measures aimed at the improvement of process energy efficiency. For example, the new Fuller cooler at the Satna plant has been retrofitted with an air beam section by IKN. A similar modification (with F. L. Smidth equipment) will be implemented shortly on the old (Birla Vikas plant) cooler. The coal mill open-type electrostatic precipitator has been replaced in the Birla Vikas plant with a baghouse, and the same replacement is planned for Satna plant.

5.4 Description of Proposed Process Changes

1. The most important problem is unstable and generally inferior quality of coal. In order to stabilize coal quality, it is necessary to create adequate-sized coal storage, complete with a stacker/ reclaimer. Construction of the coal beneficiation facility at the plant site or, preferably, at the coal mine location should be considered.

2. Replacing pneumatic conveying with mechanical systems at: (a) storage / feed silo feed from the mill, (b) kiln feed from the silo, and (c)cement silo from the cement mill.

3. Installation of Pillard three-channel coal burners on the rotary kilns. Besides improved burning conditions, this would help to volatilize chlorides coming from inferior coal.

4. Modify the cyclones at the Birla plant to reduce pressure drops and power consumption.

The following complex modifications are highly recommended for improving energy economy and general efficiency of the manufacturing process. However, an additional engineering study is required to determine both the project costs and the anticipated savings. Therefore, at this point it is premature to include the analysis of these options in this report.

1. Build new pre-blending storage with a stacker / reclaimer system, and install a tertiary limestone crusher for feeding different sizes (75 mm and 25 mm) to the roller and ball raw mills.

2. Replace five old finish mills with one finish mill, of equal or larger capacity, having a high- efficiency separator and, possibly, a roller press.

3. Install a finish mill at a cooperating power plant. This will allow production of blended (portland pozzolan) cement at the site where ash is generated. Vehicles transferring clinker to the power station will be used to ship fly ash back to the cement plant for production of blended cements. It is also recommended to improve the production process (eliminate rotary dryer) at the Durgapur location in West Bengal which produces blended cements with slag from steel mills.

5.5 Energy Saving Projections for Process Changes

<u>1. Construction of coal storage with a stacker/ reclaimer and the coal beneficiation facility.</u>
This project is aimed primarily at quality improvement and the stabilization of the kiln operation. Although this directly affects fuel economy by reducing the fluctuations of the ash and moisture content in coals from different suppliers, the results are difficult to quantify. However, if the

project is implemented in the full scope (including the beneficiation plant), it will improve coal quality and provide more direct energy savings. It may be assumed that reduction of quality variability would be equivalent to a 2% reduction in fuel use. If ash and moisture content were reduced by beneficiation, about 2% would be added to the fuel economy.

2. Replacing pneumatic conveying with mechanical systems.

If this improvement is implemented at the three most critical sites (storage silo feed from the mill; kiln feed from the silo; cement silo from the cement mill), the anticipated power savings are 4 kWh/t cement.

3. Installation of three-channel coal burners by Pillard on the rotary kilns.

It is estimated that this improvement would reduce the preheater off-gas temperature by 30°C, reduce carbon monoxide emissions to <0.1%, and improve kiln efficiency as a result of greater process stability. The overall effect would be equivalent to approximately 45 kcal/kg clinker, or 5% of the total.

4. Modification of the cyclones to reduce the pressure drop and power consumption.

Pressure drops across the system would be reduced by 150-200 kg/m^2, and power savings would be 2 kWh/t cement.

5.6 Cost Estimate of Proposed Process Changes

1. Construction of coal storage with a stacker/ reclaimer and the coal beneficiation facility:
Rs.170,000,000 (including coal beneficiation plant Rs.45,000,000).

2. Replacing pneumatic conveying with mechanical systems.

The total cost of three conveyor systems is approximately Rs. 36,000,000.

3. Installation of Pillard three-channel coal burners on the rotary kilns.

The cost of the burner delivered and installed is Rs.6,900,000.

4. Modification of the cyclones to reduce the pressure drop and power requirements.

The estimated cost is Rs.45,000,000.

5.7 Simple Economic Payback Based on Energy Savings

1. Construction of coal storage with a stacker/ reclaimer and the coal beneficiation facility:

Assuming the average fuel consumption of 800 kcal/kg clinker and total clinker production of 1,550,000 tpy, fuel economy would be:

a) without beneficiation   1,550,000 x 1,000 x 800 x 0.02 = 25,000,000,000 kcal/year;
b) with beneficiation   1,550,000 x 1000 x 800 x 0.04 = 50,000,000,000 kcal/year.

According to the company's data, the average fuel cost is approximately Rs.280 per 1 million kcal, the savings are:

a) Rs. 7,000,000
b) Rs. 14,000,000

Payback calculation:
a) without beneficiation   125,000,000 ÷ 7,000,000 = 18 years
b) with beneficiation   170,000,000 ÷14,000,000 = 12 years

<u>2. Replacing pneumatic conveying with mechanical systems.</u>
The anticipated savings of this improvement are 4 kWh/t cement. The annual savings at one plant (Birla Vikas) are (kWh):

800,000 x 4 = 3,200,000

At the power cost of Rs. 2.49 per kWh, the annual savings are (Rs.):

3,200,000 x 2.49 = 7,970,000

The payback calculation is:
36,000,000 ÷ 7,970,000 = 4.5 years

<u>3. Installation of Pillard three-channel coal burners on the rotary kilns</u>.
The anticipated fuel economy of this measure is 45 kcal/kg clinker. With the annual clinker production at 800,000 tons (Birla Vikas), the annual fuel savings would be (kcal):

45 x 1000 x 800,000 = 36,000,000,000

With the average fuel cost at approximately Rs.280 per 1 million kcal, the savings are (Rs.):

36,000 x 280 = 10,000,000

Payback calculation:

$$6{,}900{,}000 \div 10{,}000{,}000 = 0.7 \text{ year}$$

4. Modification of the cyclones to reduce the pressure drop and power requirements.
The anticipated power savings of this improvement are 2 kWh/t clinker. The annual power savings are (kWh):

$$2 \times 800{,}000 = 1{,}600{,}000$$

At the power cost of Rs. 2.49 per kWh, the annual savings are (Rs.):

$$1{,}600{,}000 \times 2.49 = 4{,}000{,}000$$

Payback calculation:

$$45{,}000{,}000 \div 4{,}000{,}000 = 11 \text{ years}$$

5.8 Additional Benefits

The benefits from implementation of the measures listed above cannot be limited to the direct savings outlined in the previous paragraph. For example, beneficiation and preblending coal will result in stabilization of the clinker quality. It will allow consistent production of cement of the desired grade without the need to over grind clinker to compensate for fluctuations in chemical composition. This alone would reduce the power usage by the finish mills. Removal of ash by beneficiation would alleviate the problems of buildups in the preheater.

The replacement of pneumatic conveying of kiln feed by an elevator would reduce the amount of false air in the preheater. The same effect would reduce draft in the preheater, resulting in fuel saving.

Improvement of clinker quality (by means of coal beneficiation and use of the advanced coal burner) would enable the plant to produce cement of higher market value and increase the percent of pozzolans in blended cements, thus increasing the profit margin.

5.9 Names, Addresses, Telephones of Contacts

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6. CENTURY CEMENT

6.1 Plant Executive Summary

The Century Cement Plant is located near Baikunth, District Raipur, Madhya Pradesh in India. The plant produces portland, portland-pozzolan, and portland-slag cements. The energy sources used in the plant are coal and electricity. Coal is used for heating in the kiln, and electricity is used in motors which drive grinders and pneumatic conveyor fans. According to data provided by the plant, the specific heat consumptions is 820 kcal/kg. This is somewhat higher than acceptable world standards. B benchmark of 700 kcal/kg is considered achievable in the world's best plants.

Process modifications to improve plant energy efficiency include:

1. Replacement of pneumatic conveying by mechanical conveying

2. Renovation of the raw material preparation system.

By implementing these recommendations, 7,800,000 kWh of electricity and 27,000 Gcal (107,136 MMBtu) of coal would be saved each year. This will save Rs. 29,110,000 (US$ 939,000) in energy costs each year. An average payback of 6.2. years will be realized on an improvements investment of Rs. 180,000,000 (US$ 5,800,000).

6.2 Characteristics of the Existing Process

This plant is located near Baikunth, District Raipur, Madhya Pradesh. The plant produces portland, portland-pozzolan, and portland-slag cements. Portland-pozzolan cement comprises over 60% of the total plant production, whereas ordinary portland cement production accounts for 13-15%. The rated capacity is 900,000 tpy clinker and 1,200,000 tpy cement. The plant operates two production lines rated at 1,100 and 1,700 tpd respectively. It was built originally in 1974-75 with double-string, four-stage preheater kilns, 4.1 x 64 m in size; three 65 tph open-circuit ball raw mills; and three 40 tph and one 65 tph open-circuit, compound, 3-compartment finish mills. In 1993, kiln No. 2 was modernized by adding a Mitsubishi fluidized-bed calciner (MFC) and an additional stage in one of the preheater lines as well as an additional 65 tph finish mill No.5 identical to mill No.4.

The plant has a unique raw material situation. It uses only one component, limestone with 76.8-79.5% calcium carbonate, with only an occasional addition of iron ore in the proportion of about 0.3%. The limestone passes through a 400 tph primary crusher and two 250 tph secondary crushers before transfer to storage.

The raw meal composition is controlled by volumetric and gravimetric chemical analysis. These methods are presently considered outdated primarily because of the slow response. However, they are acceptable under the unique plant conditions, where the means to correct raw meal are limited. As a result, the chemical composition of clinker fluctuates within a relatively wide range (lime saturation factor varies from 0.81 to 0.96). Nevertheless, the cement quality consistently meets standard requirements, although sometimes at the price of over grinding (Blaine specific surface approaches 4,000 cm^2/g even for ordinary portland cement).

The principal problems encountered in the plant's operation stem from the poor and highly variable quality of coal. Coal purchased at the spot market has ash content sometimes exceeding 40% and fairly high moisture content. Moreover, these characteristics differ in shipments from different suppliers which makes it especially difficult to control the clinker composition. Similarly, kilns operation is also affected by the coal quality. The addition of better quality Assam coal increases the sulfur level in the system. This sometimes leads to buildups in the precalciner.

6.3 Energy Intensity of the Existing Process

The kiln operation is the most fuel-consuming part of the process. It is characterized by moderate heat requirements. According to the data provided by the plant, the specific heat consumption is 820 kcal/kg. This is somewhat higher than is usually accepted as an industry benchmark, and the kiln optimization would be desirable. Presently, control of coal consumption and its varying characteristics is not consistent.

Brief observations of the kiln operation did not indicate any obvious deviations from common practice. The temperature profiles of the kilns appear normal, although gas analysis data were sometimes erratic.

Table 6.1 summarizes the electric power use by the production departments.

Table 6.1   Power Consumption in Production, kWh/t clinker

	1993 - 94	Jan. 1995
Crusher	4	2.4
Raw mill	34	33.7
Kiln / coal mill	35	36.2
Finish mill	42	42.4
Total	**115**	**119.5**

The total energy consumption is satisfactory, considering the use of some obsolete equipment. This is especially true for the finish mill section which operates with old open-circuit mills.

In general, the plant is operated with energy conservation in mind. The production of blended cements is just one example of this approach. Other measures taken recently include installation of the new radiant heat exchanger used to cool preheater gas before it enters the baghouse (kiln No.2). This reduces the pressure drop across the system by 80 kg/m^2 as compared to the original annular tube heat exchanger.

The plant management is considering some other energy-saving measures:

- Replacement the open-circuit finish mills with modern closed-circuit mills and pregrinders
- Installation of slag dryers
- Modification of grate coolers with installation of state-of-the-art air-beam grates

6.4 Description of Proposed Process Changes

1. Replacement of pneumatic conveying systems (for raw meal from raw mills to silos; for kiln feed from silos to kilns; for cement from finish mills to cement silos) with mechanical (bucket elevator) conveying.

2. Renovation of the raw material preparation system with installation of tertiary crusher to optimize the ball mill capacity and construction of a stacker/reclaimer for preblending limestone

In addition, major energy savings would be realized by expansion and modernization of fly ash and slag handling. Fly ash presently used by the plant has sufficient fineness (Blaine specific surface over 3000 cm^2/g) for use in blended cement without grinding, if an efficient blending can be provided. Blast-furnace slag is presently introduced into portland-slag cement without drying. A dryer, preferably utilizing some waste heat, would increase the mill throughput and improve quality. However, the cost of such measures can be estimated only on the basis of a detailed engineering study and tender offers from prospective suppliers.

Construction of a pre-blending coal storage and coal beneficiation plant is attractive for coal quality stabilization and improvement, but the plant has no immediate plans in this direction, and the cost estimates are not available.

Among other modernization options are the installation of a precalciner on the kiln No.1 (identical or similar to that on kiln No.2) and conversion of the finish mill department to modern technology utilizing closed-circuit mills with high-efficiency separators and pre-grinders. The first option, which would result in production increases, requires a thorough analysis of available raw resources. A complete overhaul of finish grinding may be justified only in the case of expanded production. It should be noted that the existing mills are not suitable for conversion to the new technology because of their physical dimensions.

6.5 Energy Saving Projections for Process Changes

<u>1. Replacing the pneumatic conveying systems with mechanical conveying</u>.
If this is implemented on both production lines, it is estimated that power savings of 3.5 - 4 kWh per ton of cement will be achieved (the manufacturers of material handling equipment claim greater savings).

<u>2. Renovation of the raw material preparation system.</u>
Reduction of the mill feed size after tertiary crushing will result in net power savings of 8%, or approximately 2.5 kWh per ton. Better kiln feed homogenization affects the kiln performance in

many ways, but, based on the available experience, the overall result can be estimated as an equivalent fuel economy of 4%, or 30 kcal/kg clinker.

6.6 Cost Estimate of Proposed Process Changes

1. Replacing the pneumatic conveying systems with mechanical conveying.
Based on the manufacturer's prices for similar systems, the replacement cost of all systems at Century Cement is expected to be approximately Rs.60,000,000.

2. Renovation of the raw material preparation system
The total cost of this improvement as described above is approximately Rs.120,000,000, including Rs. 90,000,000 for the stacker/reclaimer and 30,000,000 for the tertiary crusher.

6.7 Simple Economic Payback Based on Energy Savings

1. Replacing the pneumatic conveying systems with mechanical conveying

The anticipated savings are 4 kWh/t cement. The total annual savings are (kWh):

1,200,000 x 4 = 4,800,000

At the power cost of Rs. 2.76 per kWh, the annual savings are (Rs.):

4,800,000 x 2.76 = 13,250,000

Payback calculation:
60,000,000 ÷ 13,250,000 = 4.5 years

2. Renovation of the raw material preparation system
At the projected power savings of 2.5 kWh/t and the annual cement production rate 1,2000,000 tons, the total power savings are (kWh):

1,200,000 x 2.5 = 3,000,000

At the energy cost of Rs. 2.76 per kWh, the annual savings are (Rs.):

3,000,000 x 2.76 = 8,300,000

At the projected fuel savings of 30 kcal/kg clinker and annual clinker production of 900,000 ton, the annual fuel savings are (kcal):

$$30 \times 900{,}000 \times 1000 = 27{,}000{,}000{,}000$$

With the plant reported fuel price of Rs. 280 per one million kcal, the annual savings are (Rs.)

$$27{,}000 \times 280 = \text{Rs. } 7{,}560{,}000$$

Total annual savings (Rs.):

$$8{,}300{,}000 + 7{,}560{,}000 = 15{,}900{,}000$$

Payback calculation:

$$120{,}000{,}000 \div 15{,}900{,}000 = 7.5 \text{ years}$$

6.8 Additional Benefits

The benefits from implementation of these measures cannot be limited to the direct savings outlined in the previous paragraph. For example, preblending limestone will result not only in kiln stabilization but also in improvement of the clinker quality. It will allow elimination of over grinding clinker to compensate for fluctuations in chemical composition. Furthermore, use of different grades of limestone would be feasible in the future when current deposits are depleted.

Replacement of the pneumatic conveying of kiln feed by a bucket elevator would reduce the amount of false air in the preheater. The same effect would reduce draft in the preheater, resulting in fuel savings.

Improvement of clinker quality (by means of better raw meal control) would enable the plant to produce cement of higher market value and increase the percent of fly ash and slag in blended cements, thus increasing the profit margin.

6.9 Names, Addresses, Telephones of Contacts

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7. POTENTIAL EQUIPMENT SUPPLIERS

The leading U.S. supplier of the process and pollution control equipment for cement manufacturing is Fuller Co. of Bethlehem, Pennsylvania. The company is represented by a joint American-Indian entity in India (Fuller KCP, Madras). Fuller Co. is a member of F. L. Smidth - Fuller Engineering Group, and the product lines and know-how of both Fuller Co. and F. L. Smidth & Co. of Denmark are fully integrated throughout the world.

Other U.S. companies supplying major process equipment are:

Allis Mineral Systems, Waukesha, Wisconsin - pyroprocessing, crushing, grinding, dust collection equipment. The company is represented in India by a joint venture.

Nordberg, Inc., Milwaukee, Wisconsin - crushing equipment. The company is presently planning to increase its presence in India.

ABB Raymond, Lisle, Illinois - grinding and coal-firing equipment

The following companies specialize in pollution-control equipment:

BHA Group, Inc., Kansas City, Missouri
Research Cottrell, Sommerville, New Jersey
Flex-Kleen, Inc., Itasca, Illinois

8. BASIS AND ASSUMPTIONS

Evaluation of the physical advantages accrued by the suggested upgrading of the process systems is based on estimates discussed with the plants' technical and managerial personnel. Calculations of financial benefits are based on the annual report data submitted by each company during the preliminary visits by Holtec and covering the fiscal years from April 1991 through March 1994. The data were updated during our plant inspection in March 1995 to include the latest monthly results from January and February 1995. The energy costs are established by the government of India as Rs. 2.22 per kWh (Rajasthan); Rs. 2.76 per kWh (Madhya Pradesh). The equipment prices are based on the suppliers' quotations when available.

APPENDIX A

Glossary & Registered Trademarks

Glossary & Registered Trademarks

Glossary

BALL MILL - horizontal rotating cylinder containing steel balls as a grinding media.

ID (induced draft) FAN - a centrifugal fan for removal of combustion products from a kiln or furnace.

POZZOLAN - siliceous and aluminous material which in finely divided form chemically reacts with portland-cement paste to form compounds with cementitious properties, thus supplementing cement.

PREHEATER - installation for heating raw meal using energy (heat) of the kiln off-gas.

PRECALCINER (CALCINER) - a kiln system including an external furnace in which cement raw meal is heated to a higher temperature than in a preheater.

VERTICAL MILL - grinding and drying machine wherein grinding is performed by rollers pressed against a rotating table or ring, and drying, by a hot gas stream.

XRF (X-ray fluorescent analysis) - determination of chemical composition by exposing a sample to X-rays and measuring spectra of the resulting secondary radiation.

Registered Trademarks:

F. L. Smidth & Co, Denmark
ATOX
FOLAX
SEPAX
Polysius Corp., Germany
DOPOL
Polycom
Mitsubishi, Japan
MFC

APPENDIX B

Photographs

Shree Cement

1. Modernized (low pressure drop) cyclones at the top stage of the preheater
2. Central control room

Shree Cement

3. Bucket elevators replacing pneumatic conveyors at the storage silo (left) and kiln feed (right).

Mangalam Cement

4. Kiln department
5. Rotary kiln with a tertiary air duct and a dust collector

Mangalam Cement

6. Feed end of the kilns with pneumatic conveying of raw meal
7. Open circuit finish tube mill